Memoirs of the Geological Survey.

EXPLANATORY MEMOIR

TO ACCOMPANY

SHEET 20 OF THE MAPS

OF THE

GEOLOGICAL SURVEY OF IRELAND,

INCLUDING THE

COUNTRY AROUND BALLYMENA, GLENARM, CONNOR, AND THE MOUNTAINOUS DISTRICT WEST OF LARNE.

BY

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WITH

PALÆONTOLOGICAL NOTES BY W. H. BAILY, F.R.S. (Acting Palæontologist).

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PREFACE.

THE district described in the following Memoir has been geologically surveyed by the author, Mr. R. G. Symes, and forms a portion of the great volcanic region of county Antrim, bordering on the eastern coast. It is economically of great importance from the extent of the upper basaltic sheets, under which the pisolitic iron-ore is *generally* to be found. The extent of the occurrence of this mineral, and the phenomena connected with its presence, are detailed by Mr. Symes, who also clearly indicates the difficulties, physical and commercial, which have to be encountered in mining.

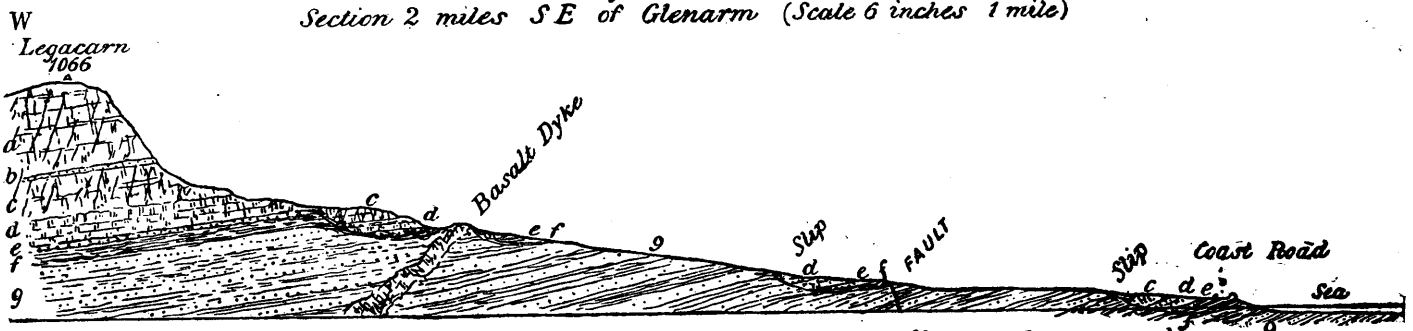
The geological survey of the district here described was originally undertaken, in 1876, by Mr. W. A. Traill; but, before it had proceeded far, Mr. Traill left the public service, and the work was taken up, in 1881, by Mr. Symes, who has made use of some of the notes and observations recorded by his predecessor.

EDWARD HULL,
Director.

5th May, 1886.

Fig 1.

Section 2 miles S E of Glenarm (Scale 6 inches 1 mile)



a Upper Basalt, b. Bauxite, c Lower Basalt, d. Chalk, e. Upper Greensand, f Lias, g New Red Sandstone.

EXPLANATORY MEMOIR

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GEOLOGICAL SURVEY OF IRELAND.

Introduction.

The district about to be described lies wholly in the county Antrim, and contains the important town of Ballymena, and the villages of Broughshane, Glenarm, and Connor.

Chapter I.

Physical Geography.

The chief river of the district is the Maine which flows in a southerly direction into Lough Neagh (sheet 28), and drains about two-thirds of the area under description; its tributaries are the Clogh, the Braid, and the Kells or Glenwhirry, all flowing from the east.

The minor rivers on the east of the watershed are the Larne water, flowing north-east; and the Glenarm river with its two tributaries, the Owenclough and Skeagh, flowing north into the sea at Glenarm.

The watershed enters the district on the south-east, and passes in a north-easterly direction towards Shane's Hill (1,044), thence northerly to Agnew's Hill (1,558), then westerly across the Star Bog, Creeve (1,186), Glen Head (1,287), and Douglas Top (1,316), then in a north-north-east direction across Tiftarney (951), Kane's Hill (938), and Drummore (865), and passes out of the district a little west of Glenarm.

A great ice sheet which was one of the denuding agents formed the principal valleys that seems to have entered the district near Glenarm, and spread itself in a fan-shape south-west and south along the valleys now occupied by the Braid and Glenarm rivers; the former stream flowing south-west in the same line as the ice moved, and the latter flowing in an opposite direction.

This great eroding agent in its south-west passage terraced the hills on the north, such as Neill's Top (1,040), Knockramer (1,106), Slievebane (1,326), and on the south Lisle's Hill (810), Slemish (1,437), by partially removing the almost horizontal sheets of Upper Basalt, and transferring fragments of them to the low ground between Broughshane and Ballymena, where it is probable it met and amalgamated with another great ice sheet coming from the south in the Lough Neagh direction; and, traversing the valley of the Maine passed north-west along the district now occupied by the large alluvial flats and boggy ground near Killagan and Glarryford (Sheet 13).

The valley of the Kells river was probably occupied in a similar manner, by the sheet which moved south along the Glenarm valley passing over Skeagh (1,127), Creeve (1,186), and turning south-west along the Glenwhirry river. The valley of the Clogh river in the north-west of the sheet also follows the direction of the glaciation.

In the east of the district the basalt presents on the sea face lofty escarpments, at the base of which the aqueous rocks are to be found. These cliffs have been formed along parallel faults and land slips; and by subaerial denudation, and possibly also by marine action when the sea was at a somewhat higher level than at present; but the process of erosion is still in progress.

The faults along the coast follow to a certain extent a N.N.W. and S.S.E. direction, which corresponds with that of the elevation owing to which the whole of the rocks over a large area are slightly tilted; giving the volcanic as well as the aqueous rocks a slight inclination to the S.W.

The landslips below the escarpments have been very numerous and have made such confusion in the rocks that the true geology of the subjacent ground is rendered very indistinct. The frequency of the landslips is due to the great pressure of the superincumbent masses of Chalk and Basalt on the Lias clays and Keuper marls. The latter are charged with moisture which is supplied from the great flow of waters between the Chalk and the Lias, converting the shales into a pasty mud which wells out and slips down the slope of the hills into the low ground.

All along these escarpments, principal springs come from beneath the Chalk; while minor springs issue from the boundaries between the basalt and chalk, and between the latter and the Lias and Triassic marl.

Chapter II.

Formations or Groups of Rocks entering into the Structure of the District.

Name.		Colour on Map.
Recent Accumulations.	Peat (Bog) Alluvium and other superficial covering,	*Pale sepia.*
	Drift or Post Pliocene, .	*Engraved dots.*
	Tertiary Volcanic Rocks.	
	B Upper, Basalt sheets, .	*Burnt carmine, deep tint.*
	Pisolitic iron ore, Lithomarge, and Ash,	*Vermillion, very pale; gold dots on outcrop of ore.*
	B Lower, Basalt sheets .	*Burnt carmine, light tint.*
	Bs, Volcanic Ash, .	*Do. with white dots.*
	B↑, Basalt dykes and necks (intrusive),	*Do. deep tint with wash of carmine.*
	Tp, Trachyte porphyry and Rhyolite.	*Vermillion.*
	Aqueous Rocks.	
Cretaceous,	h^5 Upper Chalk with Flints,	*Pale Emerald green.*
	h^4 Upper Greensand, . .	*Do. (deeper tint).*
Liassic, .	g Lower Lias and f_q Rhætic beds, . . .	*Chalons brown.*
Triassic,	. f^6 Keuper Marl, . . .	*Venetian red with wash of Indian ink.*

Triassic Beds.

Keuper Marls.—The beds of this division are found in their true position at Drain's Bog, on the east of the district, but they occur in many places north and east of this, being exposed along the coast in landslips. In Drain's Bog they consist of red and gray marls alternating. Along the shore the formation is well represented by more or less horizontal beds of red and green marl, and one thin bed of sandstone. The marls break up into small fragments, and weather soft, and plastic, and are mottled with green circular spots and strings; the green mottled beds are the water bearing strata.

Liassic Beds.

Liassic and Rhætic Beds are but sparingly represented, and are generally found in thin bands among the confused masses of rock brought together by landslips near Glenarm. At Little Deer Park, Drain's Bog, and Sallagh Braes, the highly fossiliferous blue clays have welled out into the low ground, carrying with them the Upper Greensand, and sliding apparently over the red marls of the Keuper division.

Mr. Ralph Tate, in a paper on the Lower Lias, gives the following description of the succession of beds in the Little Deer Park, one mile south of Glenarm.*

(*a*) Black shale, with a few bands of gray argillaceous sandstone, with *Axinopsis Ewaldi* (*Schizodus Cloacinus*), *Avicula contorta*, &c.

(*b*) Gray and yellow marly sandstone.

(*c*) Black shelly, laminated sandstone, with *Ostrea irregularis*.

(*d*) Blue clay with nodular and bedded shelly limestones containing *Ammonites Johnstoni*.

Beds *b* and *c* represent the zone of *Ammonites planorbis*; whilst the shales of series *a* are referable to "the *Avicula contorta* beds" (Rhætic) which comprise a moiety of the whole section, having a thickness of about 40 feet.

Near the village of Glenarm the Greensand, Lias, and Triassic beds, are not exposed owing to drift accumulations, but it is highly probable that if trials were made at Glenarm Castle all would be found to be represented.

CRETACEOUS.

Upper Greensand.—A great *hiatus* exists between this series and that just described,† the greater part of the Lower and the whole of the Middle and Upper Lias, and the Jurassic strata being unrepresented in this district.

The Greensand is but poorly indicated, being but a layer of some inches in thickness along the base of the Chalk, and is often carried with the Lias into the low ground in a broken state.

It is soft, friable, and sandy, containing particles of glauconite. Fossils abound in it. In this district it differs from that in the district to the north, inasmuch as in the latter the formation consists of a pebble bed composed almost entirely of vein quartz pebbles about the size of a pigeon's egg.

Upper Chalk.—This is locally called "white limestone," and is quarried all along the coast in large quantities and exported, more especially in the neighbourhood of Glenarm.‡

Mr. Traill notes of the Glenarm quarry:—

"These quarries in the Chalk are composed of hard white limestone, with an average dip S.S.E. from horizontal to 5° or 6°, in thick beds with flint nodules in layers three to four feet apart; portions of these beds being very firm flints.

"There are several jointage planes with cracks, fissures, or small faults, these range S. 40 E. at 60° S.; E. 35 N. vertical; N.N.W. at 60° E.; N. and S. at 85° E.; and E. 15 N. vertical.

"Fossils are present, but not very abundant—*Belemnites*, *Rhynchonella plicatilis*, and *Terebratula* being most common.

"The junction of the overlying basalt is met with in the watercourse, the intermediate agglomerate of ferruginous clay and flints with ochre bands is well exposed, being from two to four feet thick, but with uneven surface; the chalk expanding into pockets even to a depth of 20 feet."

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* Geol. Soc. Lon. Journal, Vol. xxiii. p. 300.

† Hull—Physical Geology of Ireland, p. 52.

‡ Guide to Belfast, p. 48.

This uneven surface between the Chalk and basalt has always been noted where the section is clearly seen. The hollows are due to denuding or erosive agencies; the gravels being chiefly composed of rounded flints of a bright red colour. In other parts of Antrim beds of lignite and pisolitic ore form a junction between the chalk and the overlying sheets of amygdaloidal basalt.

Two miles south of Glenarm the chalk seen in the escarpment is very fine-grained, compact, hard, though apparently not indurated by the contact of the overlying basalt,* and of a milk-white colour, some pieces resembling lithographic stone. Although compact, it is penetrated by numerous water bearing joints, and the workable beds for burning are separated by bands of flints, three to four feet apart.

Apparently fossils are scarce, but Professor Hull has shown that under microscopic examination the entire structure is composed of minute organisms †. Similarly, Mr. Joseph Wright of Belfast, has also shown that the siliceous dust in the hollow flints is composed of silicified foraminiferal shells, &c.‡

South of Drumnagreagh, which is about four miles south of Glenarm, the boundary between the Chalk and basalt is well marked in the escarpment, about 700 feet above the sea; but the thickness of the Chalk cannot in any way be calculated, owing to the amount of talus, &c., at the base. East of this, in the low ground, we also get the Chalk underneath the lower basalt, and brought down, as already stated, by the downthrow fault on the east. From the evidence in the low ground we must assume the Chalk to be of considerable thickness, as it is found dipping at 50° for a short distance; but it would be unwise to base a calculation on this, as from the landslips there might be a repetition of the strata. Professor Hull estimates the maximum thickness of the Chalk of the Co. Antrim to be about 350 feet.§ Mr. John Kelly estimates the maximum thickness at 202 feet from measured sections,‖ but it is improbable that in any part of this district it exceeds 150 feet.

At Slieve-Scawt the chalk has been carried up with the basaltic mass forming the volcanic neck. By igneous action it has been converted into a highly crystalline, saccharoidal marble.

Tertiary Volcanic Rocks.

The volcanic products in the district are divided into the *acid*, represented by trachyte-porphyry, pitchstone, &c., and the *basic*, by the basalts, of which there are two principal outflows, an Upper and Lower, separated by beds of lithomarge, pavement, and pisolitic iron-ore.

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* "The Chalk of Antrim," by J. Beete Jukes, Geo. Magazine, part 50.
† Explanatory Memoir, Sheets 21, 28, and 29.
‡ Trans. Brit. Assoc. 1874, page 95; Report Belf. Nat. Field Club, 1873-74.
§ Hull, "Geology of Ireland," page 55.
‖ Trans, Royal Irish Academy, Vol. x., page 270.

These basaltic eruptions have been assigned to the Miocene period from the plant remains found above the pisolitic iron-ore bed, and the base of the Upper basalt. One thing is certain, that the volcanic rocks must be newer than the Cretaceous system. A considerable period must have elapsed between the sedimentary rocks, and the outpouring of the volcanic products, from the fact of inequalities existing over the present upper Chalk surface, showing that they were at least partly, eroded out after the Chalk had been solidified.

Trachyte-porphyry.—The great mass well exemplified in the Sheet south of this (Sheet 28), and so well known in the north of Ireland as "Tardree trachyte," and locally called "granite" comes into the southern edge of the district, but is not well exposed, owing to the line of country along which it occurs being thickly covered with Drift accumulations.

Formerly it was supposed that this rock did not exist north of the Glenwhirry river, which flows through Kells in the S.W., but several exposures have lately been discovered. Even so far north as Clogh, in the extreme N.W. of the sheet, numerous fragmentary pieces of the porphyry are found in a confined area, which leads to the supposition that it may extend even north of this, and would be observed if the Drift were removed.

Near Speerstown three miles east of Kells the trachyte is porphyritic, containing crystals of sanidine, and blebs of smoke-quartz in a gray felspathic matrix turning a whitey brown on exposure; other crystals have been detected by the microscope such as biotite, plagioclase, tridymite,† &c.

At Esterstown, three miles N.E. of Kells, a disintegrated porphyry of similar composition was found in the road cuttings and fences. This mass lies partly in the lower and partly in the upper basalts. As in the other trachyte exposures, its actual contact with the surrounding rocks cannot be seen. (See Fig. 2.) At Kirkinriola two miles N. of Ballymena, similar evidence of its presence in a decomposed state was obtained‡ This mass comes near the base of the upper basalts.

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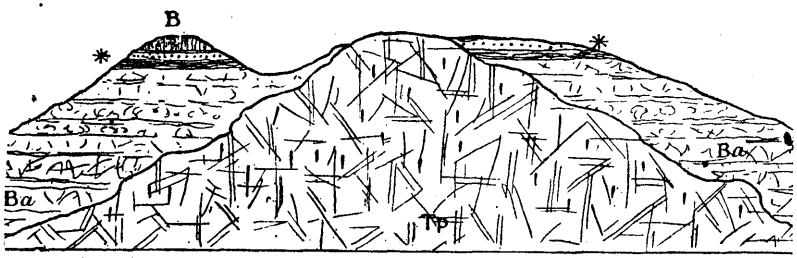
* These beds have been described by Mr. Baily, Jour. Geo. Soc. Lon., Vol. lxv., page 357. and more recently by Mr. Starkie Gardner. Vols. xxxviii. and xxxix., Palæontographical Society.

† Discovered by Professor Von. Lasaulx, Breslau.

‡ This was pointed out to me by Mr. Knowles of Ballymena.



Tp *Trachyte Porphyry.* B. *Upper Basalt.* Ba. *Lower Basalt*
* *Pisolitic Iron Ore and Pavement.*

FIG. 2.—Diagrammatic section at Esterston, to show the relations of the basaltic beds to the trachyte-porphyry, at Estertown, East of Ballymena.

A mile N.E. of Kirkinriola near Quarrytown, a mass of grayish white trachyte with nearly vertical fluxion-structure, containing small crystals of sanidine rises among the lower basalts seen in the adjoining fields. A similar mass is seen in the boggy ground near the Cloghwater Meeting-house, four miles N. of Ballymena. When examined with the lens it presents a very peculiar finely laminated appearance of fluxion-structure. It weathers white like felsite, the unweathered portion being pink. The laminæ stand in a vertical position, and remind one of the structure of slate or shale.

Lower Basaltic Series.—This is found always in great sheets composed of vesicular, amygdaloidal, scoriaceous, and spheroidal augitic lava. Between the sheets traces of decomposed basalt and bole beds are generally found, showing that after the outpouring of each sheet, time elapsed for disintegration.

The sheets occur more or less regularly, similar to sedimentary rocks, having a general inclination of a few degrees to the S.W. and S.S.W., and are in places terraced by denuding agents, and ice-moulded. An average of fifteen feet may be estimated as the thickness of each flow over the entire district.

Wherever there is any tendency to columnar structure the rock is very hard, crystalline, and it breaks with a conchoidal fracture.

The maximum thickness of the lower series probably does not exceed 350 feet.

In the railway cutting and quarries west of Ballymena very thin veins of steatite were observed; and in the north-east on the road to Glenarm, the amygdaloidal cavities contain frequent nests of mesotype, calcite, and natrolite.

Lithomarge, Pavement and Pisolitic Iron-Ore.—This series of deposits marks an era in the volcanic history. The representatives which comprise this group are composed of tuffs with bombs, ejected from several craters, such as that of Carrick-a-Rede near Ballintoy, apparently indicating that as they thin out

to the south of Antrim and attain their maximum thickness in the north the seat of the eruption was probably outside the north coast of Ireland. There is no evidence of any great central craters. The lower and upper basalts welled up and spread themselves out from along great lines termed "fissures of eruption."

The upward succession of this series is as follows:—The lithomarge rests on the lower basalt; the "pavement" over the lithomarge; and the iron ore on top. The thickness of the whole is irregular, probably the maximum may reach 70 feet: of this the richest ore occupies only about 12 inches, and is frequently separated from the overlying basalt by "brushings" or disintegrated amygdaloid.

In some places the pisolitic ore is absent, and its place occupied by an aluminous clay called "bauxite." On the horizon of the bauxite which seems to be a mud lava, are found charred stools of trees, and numerous leaves and cones similar to the plant remains found in the Island of Mull, which have led palæontologists to assign a Tertiary age to the volcanic beds.

The lithomarge is of a violet colour with white mottled spots, generally waxy when first quarried, but becoming sandy on exposure to the atmosphere. It slakes similar to lime. Numerous pebbles of this soft matter are to be found in the sand and gravel ridges north of Ballymena. Wherever the iron ore is found the lithomarge is always present, but there are several outliers of the lithomarge from which the pavement and iron ore have been denuded away. Traces of the lithomarge are to be found in the river N.E. of Cloghwater Bridge, also south of Corby Bridge on the Clogh river.

The passage from lithomarge to "pavement" is imperceptible, and the only difference between them is the greater percentage of iron in the latter, giving it a dull ochreous colour.

The estimated area of Upper Basalt, in the county Antrim is 167 square miles, of which about 80 square miles are included in this Sheet. Underneath this tract the iron ore has been worked very extensively in numerous places all over the district. Some of the workings have been abandoned owing to the ore thinning out, or difficulties encountered through the inclination of the beds preventing proper drainage. The chief mines are the Evishnably, Ballyleg, Rathkenny, Fallmore, Glenarm, Shane's Hill, and Kilwaughter.

At the Evishnably mine, worked by the Mount Cashel Company, the following downward section was noted;—Upper basalt (exfoliating) over five inches of clay; then pisolitic ore from one foot to one foot six inches thick, yielding 35 to 40 per cent. iron. This ore bed merges into the second quality called "the pavement," from eight to ten feet thick, which is worked according to the demand for the ore; yield said to be about 28 per cent. The third bed is violet lithomarge twenty to thirty feet thick and containing about 17 per cent. iron.*

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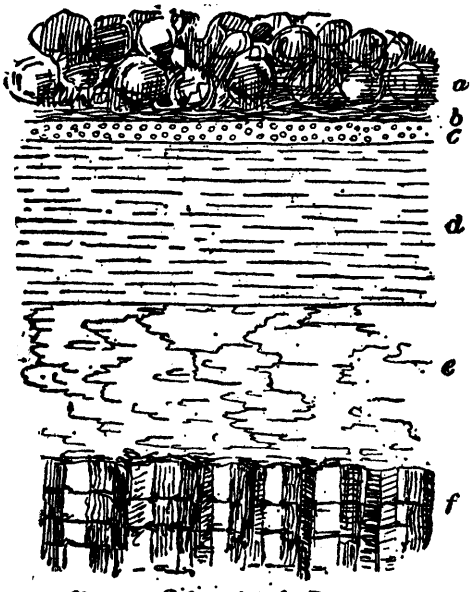
* Communicated by Captain Gillespie.



a. Upper Spheroidal Basalt
b. Soft Clay (5 inches)
c. Pisolitic Iron Ore (1 to 18 feet).
d. Pavement (8 to 10 feet)
e. Lithomarge
f. Lower Basalt

FIG. 3.—Section of volcanic beds at Evishnably Mine.

In the lithomarge are numerous remarkable rounded basaltic blocks of various consistencies and colours, some green and streaky. Numbers of the blocks are oval, reaching to six feet long, five feet broad, and two feet thick, well rounded; and some are strongly magnetic. These blocks have probably been ejected as bombs. The form of bombs is necessarily rounded, owing to their having been shot into the air in a soft state; by rotation they become rounded or oblong, so that this shape does not necessarily indicate attrition.

In the iron-ore bed of first quality there are numerous vertical basaltic dykes which have a general bearing in a N. 25 W. direction; most of these are strongly magnetic.

At Rathkenny mine, about four miles north of Ballymena, worked by the Antrim Iron Ore Company, the out-crop of the ore-bed is under clay about five inches thick, as at Evishnably. The ore-bed is traversed by numerous basalt dykes, two in particular, which are twelve feet wide and run in a N.N.W. direction; here the lithomarge is thirty feet thick. At the entrance to the mine there is a downthrow fault of twelve feet to the south between the two adits. A little to the south-east of the adits, and near the hamlet of Carncoagh Upper, a bed of lignite replaces the ore-bed. East of Pound Bridge, one and a half miles to the N.E. of Rathkenny, the river exposes a fine section of lithomarge of a slate colour, with a highly glossy lustre. Further east, numerous trials were made, but no ore was found, although the "pavement" is present; a small E. and W. fault along the bed of the river is apparent, with downthrow to the south.

Three miles S.E. of Rathkenny, in the townland of Elginny, a company formerly worked the ore, but the mine is now abandoned. Judging from the output as lying there, it looks a rich ore. The position of the bed can be traced for some distance, not only by the lithomarge, but also by the perennial springs, which are constantly found along the horizon of the lithomarge bed.

At the mine worked by the Antrim Iron Ore Company to the N.E. of Dogherty's Bridge, near Elginny, there is a remarkable section in the river on the east bank (Fig. 4). Over the ore there are the "brushings," then columnar basalt. The ore varies in thickness up to about eighteen inches, and underneath the ore is the "pavement" of a buff colour, partly composed of volcanic ash; a small kidney shaped lump of pure magnetic iron was found in this. No lithomarge was seen here, but it is probably present underneath. Following the section down the river, the ore has been removed from underneath the columnar basalt, probably by the action of the stream, and replaced by compact waterworn gravels. A little further down the stream, basalt, ore, and pavement have been denuded away altogether, and boulder clay is found banked up against a wall of basalt and pavement. The ore of first quality, as worked here, has an average thickness of fourteen inches. No other ore is worked, as cost of cartage to Ballymena is so expensive.* No. 1 ore is estimated to contain forty per cent. of metallic iron; it is generally found in a loose, gravelly state, and not in lumps as at other mines; it is also much darker in colour.

East of the last mentioned mine, a provisional boundary has been drawn of the iron-ore outcrop along a well marked feature on the slope of the hills, viz., a change in the pasturage along a line of springs; all the pasturage below the springs is rushy and very swampy; above it is dry and sound. The drift along the slopes of the hills was estimated to be thick, consequently the underlying strata could not be defined.

FIG. 4.—Columnar Basalt over Pisolitic Iron Ore, Cloonetrace Mine.

* Two shillings and sixpence a cart load being the price to Ballymena, a distance of about five and a half miles; the load generally being from twenty to twenty-five cwt.

Close to the last mentioned place, and in the Brockagh water trials were made, but no ore bed or lithomarge could be found, although numerous springs from underneath a red amygdaloidal basalt burst out on both banks of the stream. Though the ore may never have been deposited here, this is good evidence for a boundary between the Upper and Lower Basalt.

A mile to the N.E. of the Brockagh water, on the high ground above Cleggan Wood, Mr. Traill notes "a bed of ochreous amygdaloid much iron stained; there is no appearance of the pisolitic bed or lithomarge." This is no doubt the horizon of the iron ore bed, and although the true pisolitic ore is not found *in situ*, the talus immediately adjoining contains fragments of it.

At Unshinagh, three miles west of Glenarm, the iron-ore has been worked, and seven adits have been driven into the escarpment about 750 feet above the sea.

The southerly adit driven through the ore proved the grains of ore to be large, but the thickness of the bed was not seen; neither was the thickness proved in second or third adit; but immediately north of this the ore was proved to be about fifteen inches, and the lithomarge to be forty feet, thick. In No. 3 adit there was a thin band of lignite from one to five inches in thickness.

In the sloping banks along the Glenarm river the outcrop of the ore is well marked. On the west bank the ore is not in quantity, but the lithomarge can be easily distinguished; on the east bank the streams from the high ground disclose good sections of the pisolitic ore resting on lithomarge. A little to the east of Corby Bridge, over the same river, the lithomarge is at least thirty or forty feet thick, the bottom not being exposed; part is a mottled yellowish brown tuff, with a good thickness of pisolitic iron ore on top; the outcrop of the lithomarge bed is inclined 1° to 2° to the N., the roof over the ore is compact basalt without any "brushings," and the first quality ore is from six to twelve inches thick.

On the east bank of the Glenarm river there is a slip parallel to the escarpment, by which the ore bed is thrown down some sixty to eighty feet; this could not be marked on the one-inch map. South of this locality, at the confluence of the Linford and Glenarm waters, beds of bole and lithomarge occur in the south bank, and in the stream lumps of pebbly ore have been carried down the Glenarm water, but the outcrop of the ore is not exposed.

On the high ground close to Ballygilbert Hill, three miles S. of Glenarm, the pisolitic ore is exposed, and an adit was driven about five fathoms and then abandoned; from the stuff on the spoil bank it seems of fairly good quality. No further trace of the ore could be found in this neighbourhood, although the basalt is well exposed in the escarpments along the horizon where the ore ought to be.

At Fallmore, about one mile west of Glenarm, where the iron-ore was first worked in this district, and was found not to be very remunerative, it is in some parts absent, in other places it is not more than eight inches thick; these workings have now been abandoned, and the roof of the mine has fallen in.

To the S.E. of Fallmore and W. of Glenarm Glebe rich pisolitic ore is worked by the Antrim Iron Ore Company. At Libbert, on the opposite side of the Glenarm valley, the ore is absent, but is replaced by its representative, aluminous clay (bauxite), which is seldom found in conjunction with the iron-ore: this clay generally has a bed of lignite over it which contain numerous plant impressions.

Similar clay separating the Upper and Lower Basalt occurs at Cullinane, two miles W. of Glenarm, where the bauxite is extensively worked by the Eglinton Chemical Company, the clays being from six inches to two feet in thickness. Great stools of carbonized trees were extracted from these deposits.

At Ballyleg, N.E. of Broughshane, Mr. Traill notes "a white fire-clay bauxite over pavement and twenty feet of lithomarge:" very close to this two adits have been driven into the ore-bed which ranges from eight inches to eighteen inches* in thickness and with a slight dip to the north. These beds are traversed by numerous dykes which have a direction nearly magnetic north and south, as at Rathkenny and other localities.

Rudely columnar basalt was also observed here close to the ore, above which was scoriaceous basalt in sheets.

On the horizon of the iron-ore, in the face of the escarpment, near Black Hill, two miles and a half S. of Glenarm, a bed of bauxite occurs, consisting of aluminous clays with small transparent crystals of calcite. The springs on either side for a considerable distance denote the position of the bauxite in the escarpment; in places it was noted to be hard and of a pisolitic nature. Without any other evidence this has been assumed as the boundary between the Upper and Lower Basalt.

On the northern slope of Agnew's Hill, in the S.E. corner of the Sheet, the bauxite clays are also to be found, but being highly siliceous are not worked.

South of Agnew's Hill the iron-ore is seen in Shane's Hill, on different levels, one down-throw fault being 200 feet.

On the south side of the fault the ore is now being extensively worked, its inclination being 1° to 12° to the W., No. 1 ore being two feet thick, containing 38 per cent. of iron; No. 2 ore, 4 feet thick and containing 28 per cent.† No dykes were noted here.

Frequently between the iron-ore deposit and Upper Basalt there occur cavities, probably due to the decomposition of the iron ore, and these cavities are lined with bunches of crystals of calcite. In some of the mines the crystals are very pure in colour, whereas in other mines they are all tinged with iron.

Mr. Argil makes special note of the poverty of a mine when crystals are frequent.‡

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* The cost of excavating first quality ore is one shilling the half ton.

† Communicated by Mr. Hugh Smith, manager.

‡ Proceedings, Royal Dublin Society, Vol. II., part iv., p. 151.

Professor O'Reilly has determined that nearly all the crystals found are calcite from their density, crystalline form, cleavage, and hardness. The following analyses of ochreous tinged crystals from the Evishnably mine was furnished by Professor O'Reilly:—

	I.	II.
Silica,	0·71	1·0
Oxide of iron and alumina,	1·10	1·4
Magnesia,	0·59	0·528
Carbonate of Lime,	96·30	96·89
Water expelled at 100°,	0·0	0·0
Water expelled at 200°,	0·0	0·0
On heating to a very high temperature below redness,	1·1	} 1·25
Carbon by difference.	0·12	
	99·92	101·06

Upper Basalt.—This division for the most part consists of compact, or scoriaceous, amygdaloidal, and vesicular sheets disposed in terrace over terrace.

No lithological differences can be traced between the Upper and Lower Basalts in this district, but in that to the north the difference, generally accepted between the two, lies in the compactness, massiveness, and columnar structure of the upper basalt, as compared with the scoriaceous, amygdaloidal structure of the lower. Absence of bole beds in the upper basalt, in contrast with frequency in the lower, is observable in the district.

Dykes.—Although nearly the entire district is composed of basalt, dykes are comparatively rare; and throughout the great escarpments stretching from Glenarm in the N.E. all along the eastern portion of the sheet there was but one small dyke noted. This remark, however, is not applicable to the workable iron ore beds where dykes are sometimes numerous.

On the shore about three miles S. of Glenarm, a large basaltic dyke, 150 feet wide, runs in an E. and W. direction; it is partly vesicular, partly amygdaloidal, and partly compact, with disseminated crystals of irridescent magnetic iron. The Chalk occurs to the north of the dyke, while red marls lie to the south.

A little N.W. of this dyke in the townland of Drumnagreagh there is a large tongue-shaped dyke running in the Chalk in a N. and S. direction. Further west, near the hamlet of Slane, on the Carnlough and Ballymena road, a dyke is traceable for nearly a mile; it is about twenty feet wide, and rudely columnar horizontally; the central portion sixteen feet wide is compact to finely crystalline; the side walls weather inwards spheroidal and in vertical bands for about two feet. Mr. Traill notes:—

"This dyke cuts through irregular and inclined beds of purple amygdaloidal basalt and semi-lithomarge or ash, with geodes of zeolites, natrolite and mesotype, and chabasite."

Mr. Traill also notes the presence of a dyke in the neighbourhood of Clogh, in the N.W. of the district:—

"This dyke runs in a N.N.W. direction, and has a columnar structure, is highly inclined at 80° to the west, and has a horizontal, as well as vertical, platy structure."

Small dykes occur in the Cloghwater river, E. of Cloghwater bridge, and N.E. of Corby bridge.

Generally speaking, the basalt in dykes fractures in great scythe-shaped pieces, at right angles to the direction of the dykes.

Probably the most remarkable eruptive mass in the Co. Antrim is that forming the mountain called Slemish, about five miles E. of Ballymena, rising 1,437 feet above the sea, and in a long narrow ridge, 4,000 feet in length by 1,000 in breadth, above the great table land of upper basalt, which forms the high ground all along the southern limits of the Braid river. This great mass seems to mark the position of a "vent" or "orifice of eruption," from which sheets of lava may be supposed to have welled out, that are now denuded away. It is filled by crystalline dolerite, with a very large percentage of olivine, and has a vertical platy structure parallel to its direction which is N.N.W.

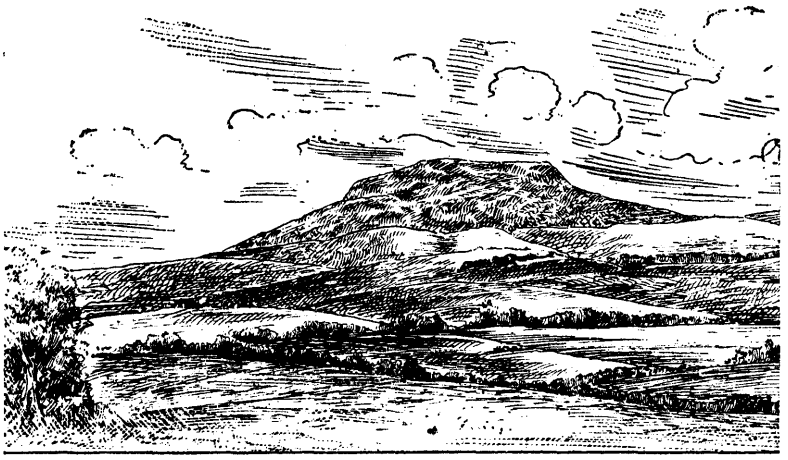

FIG. 5.—Slemish Mountain from Ballymena.

All around Slemish the evidence of ice action is very apparent, more especially on the N.E., but the steep wall of this compact mass must have been a powerful retarding impediment to the movement of the ice-sheet in its western course.

Two miles to the N.W. of Slemish the Skerry rock rises similarly in a steep wall or dyke from the plateau. It may mark another vent on the same line of weakness, but not continuous therewith; it has all the characteristics of the Slemish rock, with the exception of the vertical platy structure.

On the high ground at Drumcrow, five miles S. of Glenarm, we have another dyke-like mass along its walls the vertical platy structure, so common to dykes, is apparent; but in the centre of the mass, where the rock is quarried, there are eighty feet without this kind of jointage; olivine forms a large percentage of this rock.

To the S.E. of the dyke the tabular basalt, in horizontal sheets, is well seen abutting against the vertical walls of this rock; here also the effects of glacial action are very apparent, but the ice sheet in this case moved parallel to the eruptive mass, whereas on Slemish the direction was transverse.

Recent and Post Pliocene.

The drift accumulations are divisable into Boulder clay, Sand and gravel. The Boulder clay, as a rule, is found both on the high ground and in the valleys, and the sand and gravel nearly always lie in ridges in the valleys, having a trend generally in the direction, not only of the drainage of the district but also, of the glaciation.

Boulder Clay.—In the north-east of the district Boulder clay clothes both sides of the Glenarm valley, and the valley going into Carnlough from Ballymena. In the latter, at Doonean waterfall, it is 60 feet thick, and has a very large percentage of limestone blocks mixed with the iron-stained rounded basalt blocks imbedded in ochreous clays. The level of this locality over the sea is about 450 feet, and lies west of the outcrop of the Chalk which is about 250 feet above the sea.

Mr. Traill notes a section of drift as follows :—

"In river bank, 1,000 feet south of Glenarm Castle, on top is 8 to 10 feet of local and fluviatile debris of rolled blocks chiefly basalt, then 5 feet of boulder clay with flint, chalk, and basalt boulders, ice-scratched; then two to four inches of fine stratified sandy clay and fine gravel, and below that 6 feet of boulder clay and thin interbedded bands of fine sand and sandy semiplastic clay, in thin layers of varying thickness, the lower portion being the stiff hard blue clay (Till) with boulders."

In the N.W. of the district embraced in the map, the Boulder clay occurs in ridges or drumlins following the glaciation of the district; similarly about Cleggan and Buckna, in the centre of the district, the Boulder clay forms great banks carved out into ridges having a W.S.W. direction. The late Dr. James Bryce remarked* that there is scarcely any Boulder clay in the county Antrim from which a complete series of the rocks of the North of Ireland might not be obtained. He was also of opinion that there is evidence of transport from the west, on account of blocks of Donegal syenite and granite; this, however, does not hold good in this district.

Sand and Gravel.—To the north of Ballymena, all about Kirkinriola, Clogher, Teeshan, &c., there are large accumulations of sand and gravel having an esker form, which join in with those in Sheet 19, the hollows separating the ridges being filled with either bog, swamp, or some retentive clays. These gravels are composed entirely of detritus of the volcanic rocks, lithomarge pebbles being frequent.

On the high ground at Dunteigue Bridge, five miles S. of Glenarm, there is a good example of stratified sand and gravel containing flint pebbles, 900 feet above the sea—an exceptionally high elevation.

Mr. Traill notes the following section of current bedded Drift in the banks of Linford water, about five miles S. of Glenarm: "Top surface blends into fine sandy clays, then twelve feet of very finely laminated red clays, like brick clays, and sandy beds sloping

* On Diluvial Action, Dub. Geo. Soc. Journal, Vol. i.

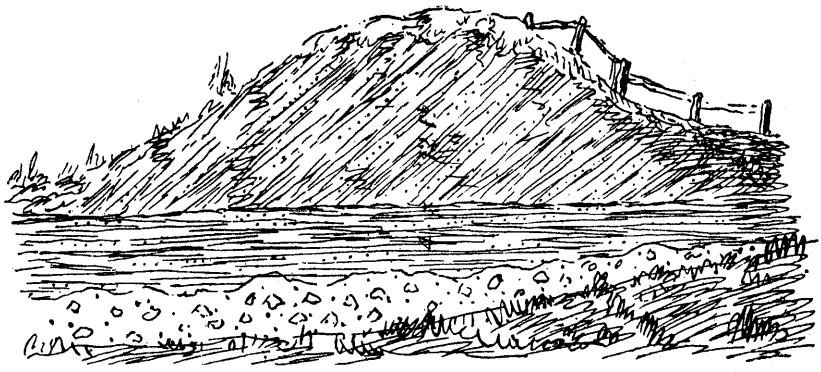

FIG 6.—Section of Drift Deposits in the banks of Linford Water, showing current bedding.

30° to the N., and these rest unconformably with a well marked line of separation on about four feet of finely laminated clays of different colours, red, brown, and pale yellow, which have a slight inclination of 3° or 4° towards the N.N.E.; part of these clays are hardened into argillaceous sandstones; underneath is genuine boulder clay, with firmly imbedded rounded and subangular boulders, chiefly of basalt, and some chalk." Dr. Grainger notes that from a bed of stratified gravel in the townland of Ballyruth, on the west side of the road, and half way between Larne and Glenarm, Dr. Jeffreys obtained a most interesting series of Post-tertiary fossils, at about fifteen feet above high water. They were as follows:—

Rhynchonella psittacea.
Mytilus edulis; fragments.
Leda pernula; in distinct layers.
Astarte sulcata, var. elliptica.
——— *compressa.*
Tellina balthica.
——— *calcaria.*
Mactra solida, var. elliptica.
—— *sub-truncata.*
Pholas crispata; fragments.
Turritella erosa.
Natica Montacuti.
——— *affinis.*
Buccinum undatum, var. undulatum.
Trophon clathratus.
Pleurotoma turricula, var.
——— *Woodiana.*
——— *Pingelii.*
Balanus tulipa-alba.

To these Dr. Grainger* added the following:—

Cardium, sp.
Cyprina Islandica.
Astarte borealis.
——— *depressa, Brown.*
Mya truncata.
Saxicava rugosa.
Puncturella noachina.
Trochus cinerarius.
Litorina obtusata.
——— *rudis.*
——— *litorea.*
Purpura lapillus.
Trophon truncatus.
Cliona, borings.
Annelide borings.

* On the Fossils of the Post-tertiary Deposits of Ireland. Brit. Ass., 1874.

Raised Beach.—Three miles S.E. of Glenarm, at Craigvullan, which is a large angular transported block 29 feet wide, 21 feet deep, and 15 feet high. Mr. Traill notes—

"That at the mouth of the stream there is an old raised beach or river delta 4 to 8 feet above high water mark. Here were found stag's horns and various bones, some split longitudinally; worked flakes, celts, and cores (of flints and scrapers), shells whole and fragmental on surface and embedded on the shaly gravels.

Artemis lincta or obsoleta.
Patella vulgata and lævis.
Litorina litorea.
„ *litoralis.*
Trochus, and other litoral shells."

Mr. Traill also describes:—

"A raised beach in Closeburn Bay 5 miles S.E. of Glenarm, and in townland of Fourscore, 4 to 8 feet above high water mark, in which was found mammoth tooth and fragment of same (both now in Dr. Grainger's collection), stag's horns and bones, many almost converted into stone, worked flints, flakes, celts, scrapers, and cores. Shells viz:—*Cyprina Islandica; Pectunculus glycymeris; Patella vulgata and lævis; Littorina litorea and litoralis; Trochus cinerarius*, &c.

Flint Implements.—Flint flakes, celts, cores, &c., are found over the entire district, not only on that portion where the chalk is subjacent, but also on the high grounds occupied by the basalt. In many places the fragmentary chips are very abundant, such as on the chalk out-crop in Drain's Bog, as well as along the out-crop S. of Glenarm, pointing out the locality where these implements were made.

Peat Bog, and Alluvium.—The high grounds are generally capped with a thin coating of peat, whereas in the lower ground it is scarce. Along the banks of such rivers as the Braid, Glenarm, and Maine, there are large accumulations of alluvium, more especially along the last named river where it is 20 feet thick and nearly a mile wide.

At the bottom of the small bogs in the low ground, stools of trees, especially oak, are found, and in one instance the growth of two successive forests was plainly observable.

CHAPTER III.

GLACIAL STRIÆ observed in this DISTRICT.

Six-inch Sheet.	Townland.	Direction.	Remarks.
27	Lisnacrogher,	N. 40 W.	
,,	Carnlea,	N. 30 W.	
,,	Crankill,	N. 39 W.	
28	Martinstown,	N. & S.	In railway cutting east of junction
,,	Crooknahaya,	N. 60 E.	In railway cutting.
,,	Longmore,	W. 15 S.	On S.W. slope of Cleggan mountain.
29	Cleggan,	W. 15 S.	
,,	Aughareamlagh,	S. W.	
,,	Doonan,	N. 35 E.	East of Doonan river.
,,	Glore,	N 10 E.	
,,	Mullagheonnelly,	N. 10 E.	
,,	Cleggan,	E. & W. W. 30 S.	
,,	Ticloy,	W. 40 S.	
,,	Tamybuck,	S. W.	
,,	Antynanum,	S. 25 W.	
,,	Ballyaddy,	S. 15 W.	
,,	Munie, North,	N. & S.	
,,	Great Deer Park,	N. 10 W.	In Glenarm domain, W. of river.
,,	Do.	W. & S.	In Glenarm domain, E. of river.
32	Galgorm Park,	N. 27 W.	In railway cutting.
33	Kinball,	E. & W. S 10 W.	In Cushendall railway cutting.
,,	Ballygarvey,	W. 35 S.	In Cushendall railway cutting
,,	Ballylig,	W.S.W.	Roches Moutonneès.
,,	Tamybuck,	W.S.W.	
,,	Carnstroan,	W. 25 S.	N.W. of Slemish ridge.
,,	Do.	E. & W.	N.E. of Slemish ridge.
34	Kilnacolpagh,	S. 35 W.	
,,	Ballynacaird,	W. 30 S.	
,,	Hughaboy,	N. 25 E.	
,,	Skeagh,	S. 35 W.	
37	Slaght,	S.S.E.	E. of O'Harastown.

MICROSCOPIC NOTES by Professor HULL.

1. *Trachyte of Ballycloghan near Ballymena.*—Of this rock two thin sections for microscopic examination were made by Mr. Cuttell of London. The rock is a compact, light gray felsitic mass, containing small grains of quartz, and a few other minute minerals, only to be determined under the microscope. With 2-inch objective the section presents a colourless mottled field, in which grains of quartz, prisms of felspar, and rather long dark indeterminate bodies, together with small black octohedral crystals of magnetite are distinguishable, but all in small quantities. The felsitic paste is slightly clouded with ochreous infusion. With the polariscope, well formed crystals of sanidine, and a very few of plagioclase can be determined; and with $\frac{1}{4}$-inch objective the longish black prisms appear to be those of hornblende. One of these, specially large, shows a brownish colour, fibrous structure, and is frayed at the ends. No forms of apatite were observable. To sum up;—the following minerals occur in the felsitic groundmass:—1, Quartz; 2, Sanidine; 3, Plagioclase; 4, Hornblende (?); 5, Magnetite.

2. *Dolerite of Slemish.*—Largely crystalline granular dolerite. With the 2-inch objective the whole mass presents a reticulated surface owing to the interlacing of the several minerals without much definition of form, the minerals being augite, olivine, plagioclase, and irregular grains of black magnite or titaniferous iron ore.

The olivine occurs in sub-crystalline grains, and rounded or shapeless

masses ; and, as it is quite unaltered, polarizes vividly ; it forms probably one-third of the entire mass. The augite occurs, filling in the interstices amongst the more definite forms of felspar and of olivine. The plates and prisms of felspar present the well-defined parallel banding characteristic of Labradorite. Under the polariscope the play of colours on rotating the analyzer is extremely rich.

PALÆONTOLOGICAL NOTES, Sheet 20.

LOCALITIES from which Fossils were collected.

No. of Locality.	Quarter Sheet of 6-inch Map.	County and Townland.	Situation, Geological Formation, and Sheet of 1-inch Map.
		ANTRIM.	
1	29/2	Aughareamlagh, .	A little north-east of Drumslishna on west bank of Glenclo River, two miles west of Glenarm. Hibernian Greensand, Chloritic Sandstone, Upper Greensand.
2	29/2	Demesne, Upper, .	Glenarm quarry, quarter mile west of Glenarm Castle. White Limestone, Upper Chalk.
3	29/2	Townparks, . .	Large quarry at north-east end of Glenarm on Coast-road. Upper Chalk.
4	29/2	Libbert, West, .	Level at Libbert mine a little west of Mullaghane Hill, one mile south of Glenarm. Tertiary clay Miocene?
5	30/1	Little Deer Park, .	Cliffs at White Bay, one mile east of Glenarm. Upper Chalk.
6	30/1	Little Deer Park, .	Quarry at "M'Auley's Head," one and a quarter miles south east of Glenarm. Upper Chalk.
7	30/1	Little Deer Park, .	One and three quarter miles south-east of Glenarm, half a mile south of M'Auley's Head on Coast-road. Grey Limestone, Shales and Clay, Rhætic and Lower Lias.
8	30/1	Little Deer Park, .	West of Coast-road, half a mile south of M'Auley's Head, one and three quarter miles south-east of Glenarm. Upper Chalk and Chloritic Chalk.
9	30/1	Little Deer Park, .	Old quarry on Coast-road, half a mile south of M'Auley's Head, one and a half miles south-east of Glenarm. Upper Chalk.
10	30/1	Minnis, North, .	Rocks in small stream, half a mile south-east of "The Moat," two miles south-east of Glenarm. Chloritic Chalk.
11	30/1	Minnis, South, .	A little east of old-road from Larne to Glenarm, two miles south-east of latter. Upper Chalk.
12	30/3	Drumnagreagh, .	Rocks on shore a little south of Drumnagreagh Port, two and a half miles south-east of Glenarm. Upper Chalk.
13	30/3	Drumnagreagh, .	Half a mile north-west of old church on old-road from Glenarm to Larne, two and a half miles south-east of Glenarm. Lower Lias, Limestone.
14	30/3	Drumnagreagh, .	Half a mile south-west of old church on old-road from Glenarm to Larne, three miles south-east of former, close to small stream. Lower Lias, Limestone.

PALÆONTOLOGIAL NOTES—*continued.*

No. of Locality.	Quarter Sheet of 6-inch Map.	County and Townland.	Situation, Geological Formation, and Sheet of 1-inch Map.
		ANTRIM—*con.*	
15	30/3	Ballygilbert, .	Quarry on face of hill at Ballygilbert, three and a half miles south-east of Glenarm, a quarter mile south-west of National School. Upper Chalk.
16	30/3	Ballygilbert, .	Quarry side of hill half a mile west of Ballyruther, four and a half miles south-east of Glenarm. Upper Chalk.
17	35/1	Linford, . .	Small quarry, in field south side of new road from Dunteige Bridge to Carncastle National School, three quarters of a mile south-east of Dunteige, five miles south-east of Glenarm. Upper Chalk.
18	35/1	Drain's Bog, . .	Quarry north side of new road from Dunteige Bridge to Carncastle, one mile east of former. Upper Chalk.
19	35/1	Ballycoss, . .	Over one mile east of Dunteige Bridge on new road to Carncastle, five miles south-east of Glenarm. Upper Chalk with Chloritic Chalk.
20	35/1	Drain's Bog, . .	Cutting on new road, over one mile east of Dunteige Bridge. Lias, light grey Limestone.
21	35/1	Drain's Bog, . .	Rocks exposed at base of Knockdhu Mountain close to stream, one mile west of Carncastle Church, six miles south-east of Glenarm. Upper Chalk.
22	35/3	Sallagh, . .	A little south-west of Tumulus at Sallagh Braes, seven miles south-east of Glenarm. Upper Chalk.

LIST of the FOSSILS collected from the LOCALITIES mentioned in the preceding TABLE.

The numbers opposite each species refer to the places at which they were collected, and the × placed before some of them is intended to denote their comparative abundance.

TRIASSIC—RHÆTIC.

LAMELLIBRANCHIATA.

	Localities.
Axinopsis Ewaldi, ...	7.
Pecten Valoniensis, ...	10.
Placunopsis Alpina, ...	7.
Small bivalves of the genera Anatina, Axinopsis, Myacites, Placunopsis, &c., ...	7, 12, 14, 20.

JURASSIC: *Lower Lias.*

ECHINODERMATA.

Extracrinus Briareus, ...	7.
Cidaris Edwardsii, ...	7.
Hemipedina Bechei, ...	7, ×12.
Ophiolepis Murravi, ...	–

ANNELIDA.

Serpula, sp. on Ammonites Johnstoni, . . . 7.

	Localities.
Brachiopoda.	
Rhynchonella, sp.,	7.
Lamellibranchiata.	
Anatina myacina,	7.
Astarte Gueuxii,	×7.
Avicula Pattersoni,	7.
Cardinia ovalis,	×7.
,, Listeri,	7.
Lima gigantea,*	×7.
Mytilus Hillanus,	19, 20.
,, minimus,	7.
Ostrea irregularis,	××7.
Pecten dextilis,	7.
Cephalopoda.	
Ammonites Johnstoni,	×7.
Reptilia.	
Ichthyosaurus, sp. vertebra,	7.

UPPER CRETACEOUS: UPPER GREENSAND: UPPER CHALK.

Amorphozoa.	
Coscinopora infundibuliformis,	1.
Annelida.	
Vermicularia concava,	1, × 10.
Brachiopoda.	
Rhynchonella latissima,	1.
Terebratula carnea,	1, 8, 10.
,, biplicata,	1.
,, obesa,	1, 10.
Lamellibranchiata.	
Exogyra columba,	10.
,, conica,	1.
,, haliotoidea?	1.
Inoceramus Cripsii?	1, 8.
Ostrea semiplana,	8.
Pecten orbicularis,	××1.
,, quinquecostatus,	1.
Spondylus spinosus,	××1.
Gasteropoda.	
Pleurotomaria perspectiva?	1.
Nerinæa,	10.
Pisces.	
Corax falcatus, teeth,	10, 19.
Lamna acuminata, do.,	×10.
Otodus appendiculatus,	1, 10.
Fish vertebræ,	10.
Amorphozoa.	
Amorphospongia perreticulatum,	6, 15, 17, 18.
Cliona cretacea, in Belemnitella mucronata,	17.
Coscinopora infundibuliformis,	5, 8, 16, 19.
Ventriculites decurrens,	19.
,, radiatus,	5, 19.

* Lima gigantea and L. pectinoides, I believe to be synonyms.

ACTINOZOA.

	Localities.
Parasmilia centralis,	8.

ECHINODERMATA.

Echinoconus conicus,	6.
Echinocorys vulgaris,	2, 8, 18, 19.

BRACHIOPODA.

Kingena (Megerlia) lima,	2, ××3, ×5, 6, ×9, 10, 15, ××16, 22.
Rhynchonella octoplicata,	2, 3, 5, ×9, 12, 15, 16, 17, 18, 21.
Terebratula carnea,	9, 10, 12, 15, 18.
,, semiglobosa,	2, 5, 6, ×21
Terebratulina striata,	3, 5, 11, 12.

LAMELLIBRANCHIATA.

Ostrea vesicularis,	21.
Pecten nitidus,	2, 3, 6, 15, 16, 19.
Spondylus spinosus,	5, 21.

GASTEROPODA.

Patella, sp.,	5.
Scalaria, sp.,	15.

CEPHALOPODA.

Ammonites, sp.,	19.
Belemnitella mucronata,	2, 3, 5, 6, 8, ×9, 10, 16, 17 18, 22.

PISCES.

Otodus appendiculatus,	16, 19.

TERTIARY.

PLANTÆ.

Coniferæ.

Sequoia Du Noyeri (Baily sp.), (Cryptomenia Sternbergii, Goeppert, sp.) v. Gardner.*	4.

Large trunks of trees ? coniferous, and probably the wood of this Sequoia (carbonized), with a diameter of about 5 feet, found immediately over the aluminous earth called Bauxite.

Capuliferæ.

Corylus, sp ,	4.
Quercus, sp.,	4.

Moreæ.

Platanus Guillelmæ (Göepp),	4.

Aceraceæ.

Acer, sp ,	4.

Rhamneæ.

Rhamnus, sp.,	4.

Menispermaceæ.

McClintockia Lyelli (Heer),	4.
,, trinerva (Heer),	4.

Laurineæ.

Sassafras, sp.,	4.

Araliaceæ.

Nyssa ornithobroma,	4.

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* Monograph on British Eocene Flora, by John S. Gardner, F.L.S., Palæontographical Society, vol. xxxviii., issued for 1884.

Pleistocene.

In the Townland of Ballyruther there occurs a sand pit on the coast road, about half a mile east of Playhill, five miles south-east of Glenarm.

A list of shells from this place, quoted from Rev. Dr. Grainger's paper in British Association Reports for 1874, is given on preceding pages, 21, 22. To this may be added another species, *Leda caudata*, from those collected by Mr. Clark; also the Cirripede, *Balanus tintinnabulum*, of which *B. tulipa alba* of Rev. Dr. Grainger's list is a synonym.

A molar tooth of the Mammoth *Euelephas primigenius*, now in the possession of the Rev. Dr. Grainger, is stated by that gentleman to have been found under a raised beach at Closeburn Bay, near this locality. (See also p. 22 of this Explanation).

Fossils mentioned in Portlock's Report as occurring near Glenarm, and others of the Ordnance Survey collection from the same district.

Jurassic.

Species of General Portlock's List.	*Species now adopted.*
Pachyodon crassiusculus.	Cardinia ovalis.
„ ovalis.	
Unio trigonus.	„ „
„ Listeri.	„ Listeri.
Modiola Hillana.	Mytilus Hillanus.
Ostrea acuminata.	Ostrea irregularis.
Ammonites intermedius.	Ammonites Johnstoni.
„ Johnstoni.	
„ multicostatus.	„ raricostatus.
„ MacDonnelli.	„ MacDonnelli.

Remarks on the Fossils.

The fossiliferous deposits on this sheet of the Map are all situated towards the north-east corner, near the coast line. The collection lately made by Mr. Richard Clark from this district includes Rhætic, Lower Lias, Cretaceous, Lower Tertiary, and Pleistocene forms. Except examining the leaf-beds near Glenarm, I had not an opportunity of visiting any other locality, and therefore cannot explain the conditions under which the fossils from the other, and various strata, occur. In some places there has evidently been (most probably from land slips) a mingling of Rhætic, Liassic, and Cretaceous Fossils.

Fossils from similar formations have already been catalogued and published in the Explanations to Sheets 21, 28, and 29, also 36.

The Tertiary Plant-beds at Libbert Hill, near Glenarm (locality 4), as also that at Ballyclare, near Carrickfergus (see Explanation to Sheet 21, &c., page 44), have on good authority been referred to the Miocene age. Both correspond in being interstratified with the Basalt, but are lithologically different—this near Glenarm being a light grey clay, superimposed upon the deposit of aluminous marl, called "Bauxite" (worked for economical purposes by the Eglinton Chemical Company). I am indebted to William Gray, Esq., M.R.I.A., of Belfast, for having first called my attention to these interesting fossil plants, and accompanying me to Glenarm. I am also indebted to Mr. Walter Jamieson, Mining Manager to the Eglinton Chemical Company, at Glenarm, for valuable information and specimens.

The result of this and other visits I communicated to the British Association, in a series of reports, published in 1879, 1880, and 1881. The list of species now given being derived from these reports.

Mr. J. Starkie Gardner, F.L.S., has since the publication of my reports in his monograph on "Eocene" Plants, published by the Palæontographical Society (vol. xxxviii., issued for 1884), entered more into detail as to species than I had an opportunity of doing, referring these deposits, together with those of the Island of Mull (evidently contemporaneous), to the *Eocene* period, a reference which in the face of such an authority as the late Dr. Heer and other eminent writers on the subject, must be considered of a purely speculative character.

November 12, 1885. WILLIAM HELLIER BAILY.

APPENDIX.

The following analyses and notes have been compiled by Mr. Walter Jamieson, M.E., of Glenarm.

Chalk.—Analysis of sample from Glenarm Quarry :—

Protoxide of Iron	0·10	Phosphoric acid	Trace
Alumina	0·41	Siliceous matter	0·49
*Lime	55·09	Water	0·18
Magnesia	0·23		
*Carbonic acid	43·60		100·10

In the Glenarm district the chalk beds are best developed as to thickness in the immediate vicinity of the village, and on the road towards Larne ; the thickness varies from 200 feet down to 60 or 80 feet.

Subjoined is a copy of a journal of a bore put down in the bottom of the Lower Demesne Quarry at Glenarm to prove the nature and thickness of the underlying strata ; the thickness worked at this quarry ranges from 40 to 60 feet.

	Coarse limestone, surcharged with sand	17 Feet.
A.	Coarse sandy limestone, with excess of flints	12 ,,
	Hard sandstone band	1 ,,
B.	Chloritic and Glauconitic sands	27 ,,
	Blue clay (Lias)	2 ,,

A. The imbedded flint cut through was in some cases three feet thick.

B. Fragments of jet were found in the borings of this part of the section.

The bore was stopped when it fairly entered into blue clay, as no object was to be gained by boring further.

Alum Clay.—Analyses of clays worked by the Eglinton Chemical Company, Limited :—

	No. 1.	No. 2.	No. 3.
Alumina	45·42	52·37	57·32
Iron peroxide	1·54	1·29	0·24
Lime	0·46	0·48	0·61
Magnesia	Trace	Trace	0.36
Potash and soda	0·04	0·06	0·17
Silica	24·50	13·15	11·04
Titanic acid	9·40	5·20	2·56
Sulphuric acid	0·08	0·35	0·30
Phosphoric acid	Trace	Trace	Trace
Organic matter	Trace	Trace	Trace
Combined water	18·53	27·13	27·16
	99·97	100·03	99·76

* Equal to 98·38 carbonate of lime. Specific gravity = 2·60.

Per-centage of water lost in drying the samples :—

At 212° Fahr. .	No. 1	21·60
	„ 2	17·46
	„ 3	9·83

In some districts the clays might more properly be described as siliceous clays, as silica predominates in their composition.

The following are analyses of a few examples after calcination: —

	No. 1.	No. 2.	No. 3.
Silica	67·80	74·04	55·80
Alumina	30·24	23·80	37·74
Oxide of Iron	1·00	1·00	2·01
Lime and Magnesia, &c. . .	1·01	1·06	4·60
	100·05	99·90	100·15

It may be of interest to add analyses of two samples of Bauxite (French), and one sample of Wocheinite (Austrian), for purpose of comparison with the alum clays of Ireland :—

	No. 1 Dalmis (French)	No. 2 1st Quality (French) Marseilles.	No. 3 Wocheinite (Austrian)
Alumina . . .	63·19	* 67·83	57·04
Silica . . .	11·47	10·64	19·60
Iron peroxide . .	3·72	·47	1·08
Combined water, &c.. .	16·32	15·80	17·45
	94·70	94·74	95·17

The alumina in above is both hydrated and anhydrous, and the sulphuric acid, used in the process of alum making, extracts the hydrated alumina only.

There is probably six to eight per cent. of alumina in those samples which cannot be extracted by any alum making process, and this per-centage is consequently lost.

Without going into particulars as to localities, it may be noted that the alum clays occur at many points in the country, and particularly in the district under consideration. In the majority of cases it is not up to marketable standard, an excess of iron, organic matter, or silica, rendering it unworkable by the manufacturers of alum products.

The following information was received from Mr. Robert Browne, Secretary to the Antrim Iron Ore Company, Limited.

The extensive field of iron ore which extends over the greater portion of the county Antrim, northwards from Ballymena, outcrops on the south side, in the neighbourhood of the village of Broughshane, at an elevation of about 500 feet above the sea level.

There are other smaller deposits to the south of Ballymena, but these are of minor importance, and, generally speaking, contain ore of an inferior quality.

The bed of ore has been proved to extend from Broughshane northwards towards Trostan mountain, a distance of over 10 miles in an unbroken field, and there is every reason to believe that it underlies the unexplored country between Trostan and Ballycastle.

It has been worked at Broughshane, Rathkenny, Evishnably, Glenravel, Glenariff, Trostan, and Glenarm, and at the majority of these places it is very similar in character, and yields over 40 per cent. of metallic iron as produced from the mine.

The richest ore is produced by the Broughshane mines, and the bed there is easily worked, being of a soft nature, and the only tools required by the miner are the pick and shovel.

The system of working is very simple —levels are driven into the hillside in a northerly direction, or as near as possible thereto; and as the bed of ore rises gradually in that direction, the gradient of the level permits the water from the workings to flow outwards towards the surface and no pumping is necessary.

The basaltic rock which immediately overlies the bed of ore forms an excellent roof, and very little timber for propwood is necessary.

The Broughshane ore is known commercially as "Brown Hematite," and is much in favour in the iron-making district of West Cumberland where it is extensively used in conjunction with Cumberland ore in the manufacture of Bessemer steel. Messrs. Kirk, Brothers & Co., of Workington, manufacture a special brand of bar iron known as "Antrim ore," which finds a ready market in the North of Ireland on account of its superior quality.

The Irish ore used in the production of this iron is supplied by the Antrim Iron Ore Company from their Broughshane mines.

The following is an analysis of Broughshane ore, made by Mr. Edmond G. Tosh, PH.D., who is at present manager of the Lonsdale Iron and Steel Company's works at Ulverston:—

Ferric oxide,	65·42
Manganous oxide,	Trace
Alumina,	12·54
Lime,	0·20
Magnesia,	0·08
Sulphur,	Trace
Phosphoric acid,	0·02
Titanic acid,	5·28
Silica,	7·08
Water,	8·82
	99·44
Iron per cent.,	45·99

About two miles from Glenarm the iron ore crops out on the estate of the Earl of Antrim, where it is worked by the Antrim Iron Company. The bed here is much thicker and more regular than in any other portion of the country, but the quality is not so rich in iron as the ore from the Broughshane and Glenravel districts; it contains, however, a much larger percentage of alumina, and is valuable for fluxing the rich ores of Cumberland and North Lancashire, which generally contain a high percentage of silica necessitating a heavy admixture of fluxing material.

Immediately under the upper, or No. 1, bed at Glenarm, a second, or No. 2, bed occurs containing less iron and more alumina, which is extensively worked for use as a flux.

The principal difficulty met with in working Antrim iron-ore arises from the displacement of the bed by basaltic dykes, but these have not proved troublesome at the Glenarm mines, and the working there is attended with less trouble than in the Broughshane and Glenravel districts.

The following analysis of the No. 1 and No. 2 Glenarm ores was made by Mr. Edward Riley, F.C.S. :—

	No. 1.	No. 2.
Silica,	12·93	7 81
Peroxide of iron,	57·43	35·13
Protoxide of iron,	Trace	Trace
Oxide of manganese,	Nil	Nil
Alumina,	16 92	36·66
Titanic acid,	6·45	5·44
Carbonate of lime,	Trace	1·74
Magnesia,	0·88	Trace
Sulphuric acid,	0·17	Trace
Phosphoric acid,	Nil	Nil
Combined water,	5·70	13·06
	100 48	99·84

No. 1.—Iron, 40·20 per cent.; water in ore, as received, 94·0 per cent.
No. 2.—Iron, 24·59 per cent.: water in ore, as received, 18·52 per cent.

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